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(71) **Applicant: KONINKLIJKE PHILIPS ELECTRONICS N.V.** [NL/NL]; Groenewoudseweg 1, NL-5621 BA Eindhoven (NL).

(72) **Inventors: SOOMRO, Amjad**; Prof . Holstlaan 6, NL-5656 AA Eindhoven (NL). **CHOI, Sunghyun**; Prof . Holstlaan 6, NL-5656 AA Eindhoven (NL).

(74) **Agent: GROENENDAAL, Antonius, W., M.**; Internationaal Octrooibureau B.V., Prof. Holstlaan 6, NL-5656 AA Eindhoven (NL).

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(54) **Title:** SIGNAL TO NOISE MARGIN INFORMATION FOR POWER CONTROL AND BIT RATE ADAPTATION IN IEEE 802.11H WLAN
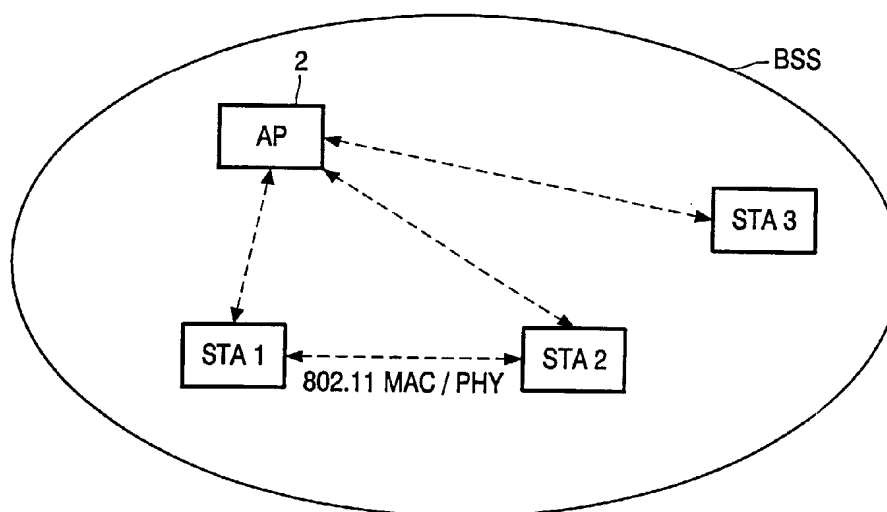
(57) **Abstract:** A method and apparatus for adjusting the transmission power level or transmission data rate between a plurality of stations located within the coverage area of a basic service set (BSS) or in an independent basic service set (IBSS) in a wireless local area network (WLAN). The receiving station extracts a transmission data rate from an incoming signal, determines a signal-to-noise ratio (SNR) for the incoming signal, and then calculates noise margin information based on a difference between the SNR of the incoming signal and a minimum SNR_{MIN} for the extracted data rate. The noise margin is then transmitted back to the original transmitting station and using the noise margin information, the transmit power level and/or the transmission rate of this station may be adjusted accordingly.

Noise margin information for power control and link adaptation in IEEE 802.11h WLAN

The present invention relates to communication systems. More particularly, the present invention relates to a system and method for providing information to the transmitting wireless stations in an IEEE 802.11 wireless local area network (WLAN) regarding the receiving wireless station's receiver capabilities.

5   In general, there are two variants of wireless local area networks (WLAN): infrastructure-based and ad hoc-type. In the former network, communication typically takes place only between the wireless nodes, called stations (STA$_i$), and the access point (AP), whereas communication takes place between the wireless nodes in the latter network. The stations and the AP, which are within the same radio coverage, are known as a basic service

10   set (BSS).

The IEEE 802.11 standard specifies the medium access control (MAC) and physical layer (PHY) characteristics for a wireless local area network (WLAN). The IEEE 802.11 standard is defined in International Standard ISO/IEC 8802-11, "Information Technology--Telecommunications and information exchange area networks", 1999 Edition,

15   which is hereby incorporated by reference in its entirety.

Currently, the IEEE 802.11 does not provide a mechanism to enable dynamic transmit power control between wireless stations within a BSS. Typically, each 802.11 STA uses a fixed transmission power level for all the frame transmissions throughout its lifetime. Accordingly, there is a need for a transmit power level and transmission rate adjustment

20   mechanism that can be implemented within the proposed 802.11a PHY/802.11h MAC implementation without much complexity.

The present invention is directed to a system and method of estimating receiver capability information by a receiving station, and conveying this information back to the transmitting station. The transmitting station is thereby enabled to determine accurately

25   the transmission power level or to adjust transmission rate in a wireless local area network (WLAN) for future data transmissions to the receiving station. Receiver capability information, hereinafter known as "Noise Margin", is the receiving wireless station's receiver capabilities, including the local noise/interference level, the channel path loss and the channel

conditions. Generally, the noise margin is the ratio of the received signal power to that required for effective communication.

According to one illustrative embodiment of the present invention, a method for determining the transmission power level and/or transmission rate between a plurality of

5   stations located within the coverage area of a basic service set (BSS) in a wireless local area network (WLAN) is provided. The method includes the steps of: extracting the data rate of a transmission from an incoming frame; calculating the signal-to-noise ratio (SNR) of the received frame; calculating the noise margin for the extracted data rate based on the difference of the SNR and the minimum acceptable SNR (SNR_{MIN});, transmitting the noise

10   margin information to the transmitting station and adjusting the transmit power level or the transmission rate for future data transmitted by the transmission station and/or other stations in the BSS according to the received calculated noise margin.

The present invention also provides an apparatus with a power measurement circuit for determining the received power level between a plurality of stations located within

15   the coverage area of a basic service set (BSS) in a wireless local area network (WLAN). The apparatus includes a receiver circuit for demodulating an incoming signal; an SNR measurement circuit for measuring the received SNR of the incoming signal received therein; a processor, coupled to the power measurement circuit, for calculating noise margin based on the difference of the SNR and the minimum acceptable SNR ratio for the extracted data rate;

20   a memory, coupled to the processor, for storing the calculated noise margin information for a predetermined time period for a subsequent retrieval; and, a transmitter circuit coupled to the processor.

The foregoing and other features and advantages of the invention will be apparent from the following, more detailed description of preferred embodiments as

25   illustrated in the accompanying drawings in which reference characters refer to the same parts throughout the various views.

Fig. 1 is a simplified block diagram illustrating the architecture of a wireless

30   communication system whereto embodiments of the present invention are to be applied;

Fig. 2 illustrates a simplified block diagram of an access point and each station within a particular basic service set (BSS) according to the embodiment of the present invention;

Fig. 3 illustrates the format of an 802.11 frame, including the modification of the SERVICE field, that can be used to transmit information between stations according to an embodiment of the present invention; and

Fig. 4 is a flow chart illustrating the operation steps of selectively adjusting the power level according to an embodiment of the present invention.

In the following description, for purposes of explanation rather than limitation, specific details are set forth such as the particular architecture, interfaces, techniques, etc., in order to provide a thorough understanding of the present invention. However, it will be apparent to those skilled in the art that the present invention may be practiced in other embodiments that depart from these specific details.

Fig. 1 illustrates a representative network whereto embodiments of the present invention are to be applied. As shown in Fig. 1, an access point (AP) 2 is coupled to a plurality of mobile stations (STA$_i$), which, through a wireless link, are communicating with each other and to the AP via a plurality of wireless channels. A key principle of the present invention is to provide a mechanism to enable a transmitting station to gain knowledge regarding the receiving stations' local noise/interference, channel path loss and its performance capability. This is accomplished by the receiving station estimating the noise margin, for example, at the time and for the rate at which a frame is received, and conveying this information back to the transmitting station). As noted above, the noise margin is the ratio of the received signal power to that required for a particular level or threshold of communication, (hereinafter known as effective or reliable communication between the stations), the level is based on a number of factors effecting communication, such as error rates, SNRs, as well as any other conventional measure of transmission performance. The noise margin is useful in, but not limited to, minimizing the transmitter power or other types of power control such as saving the battery power, avoiding interference to other systems, adjusting radio coverage and adjusting transmission rate, by transmitting frames at just the right power level and the right transmission rate. IEEE 802.11 Physical Layers (PHYs) define a plurality of transmission rates based on different modulations and channel coding schemes so that the transmitter of a frame can choose one of the multiple rates based on the wireless channel condition between the receiver and itself at a particular time. Typically, the lower the transmission rate, the more reliable the transmission. It should be noted that the network

shown in Fig. 1 is small for purposes of illustration. In practice most networks would include a much larger number of mobile stations.

The AP and each STA within the WLAN of Fig. 1 may include a system with an architecture that is illustrated in the block diagram of Fig. 2. Referring to Fig. 2, both the
5   AP and STA may include a receiver 12, a demodulator 14, a SNR measurement circuit 16, a memory 18, a control processor 20, a timer 22, a modulator 24, and a transmitter 26. The exemplary system 10 of Fig. 2 is for descriptive purposes only. Although the description may refer to terms commonly used in describing particular mobile stations, the description and concepts equally apply to other processing systems, including systems having architectures
10   dissimilar to that shown in Fig. 2.

In operation, the receiver 12 and the transmitter 26 are coupled to an antenna (not shown) to convert received signals and transmit desired data into corresponding digital data via the demodulator 14 and the modulator 24, respectively. The SNR measurement circuit 16 operates under the control of the processor 20 to determine the SNR, or similar
15   calculation to estimate noise margin, of a received frame. Processor 20 thereafter calculates the noise margin based on the difference of the SNR (in dB) and the minimum acceptable SNR (SNR_{MIN}) for a particular data rate. The minimum acceptable SNR for a particular data rate is determined by any of a number of methods (e.g., an error rate threshold may be used or the receiver may be configured with modulation error estimate parameters). For example,
20   'noise margin' calculated in an 802.11 compliant STA for a received PPDU may be calculated as the additional noise/interference in the PPDU in dB that could be tolerated by this STA without affecting its correct reception. As an example, if a receiver determines that a received PPDU had a signal-to-noise ratio (SNR) of 30dB and it was transmitted at 24 Mbps rate, then if the receiver could correctly receive the same PPDU at 24 Mbps with
25   signal-to-noise ratio of 24 dB (SNR_{MIN}), then it would report a noise margin of 6 dB. The noise margin is stored in the memory 18 that is coupled to the processor 20 for subsequent retrieval. The timer 22 is used to eliminate the outdated noise margin information, which is stored in the memory 18. In the embodiment, the noise margin is updated as it may change due to the varying nature of the wireless channel as well as the potential mobility of WLAN
30   STAs.

Fig. 3 represents the format of PHY Protocol Data Unit (PPDU) frame that is used to convey the noise margin information between the stations. As shown in the lowest part of Fig. 3, the noise margin information (represented by noise margin Present and noise margin) is transmitted in the SERVICE field of the 802.11a/h PPDU frame. The SERVICE

field of the 802.11a is slightly modified to include the one-bit noise margin Present field and four-bit noise margin field. The original SERVICE field 30 format of the PLCP Header 28 of 802.11a is found in the middle part of Fig. 3. The one-bit noise margin Present field 32 is defined as 0 or 1, where the noise margin field 34 may be optional in a system and presence

5   of the noise margin information is indicated by setting the 'Noise Margin Present' bit. Otherwise, the 'Noise margin Present' bit is set to zero. The noise margin field 34 is defined from 1 to 16, where each value is in decibels (dB), for example, -6 dB to +10 dB, and the field value would be based on calculations on immediate prior frame transmitted from the current destination STA. In addition, the RXVECTOR and TXVECTOR fields, which are

10   passed between MAC and PHY are modified to add noise margin information. In particular, one parameter, NOISE MARGIN, is extracted from or inserted into the SERVICE field 30 in the PPDU. The most significant bit of the currently reserved bits would be set if a valid value in present in the remaining seven bits. Else, it would be reset with a '0' value. As those skilled in the art will recognize the noise margin information could be sent by other means,

15   for example, in the MAC payload, as well as other portions of the header.

The noise margin field 34 transmitted in a current PPDU would correspond with the noise margin measurements on the immediately prior frame received from the STA that is the current PPDU's destination STA. The noise margin information is transmitted back to the transmitting station and now this station based on the received noise margin of the

20   receiver adjusts the transmission power or the transmission rate. It is noted, however, that a receiver may transmit any noise margin value it may deem appropriate to indicate to the transmitter its performance capability, presence of local interference or desire for power adjustment. After obtaining the noise margin by receiving frame(s), the receiving STA can determine both the PHY rates as well as the transmission power intelligently for its future

25   transmission to that STA. Thus, the transmission power level and rate are determined solely up to the transmitting STA's discretion.

Now, the principle of operation steps according to the present invention of determining the noise margin to determine the transmission power level/transmission rate is explained hereafter.

30   Referring to Fig. 4, the inventive process includes the following steps: in step 100, a station STA2 receives a frame from a transmitting station STA1. In step 110, the STA2 extracts the data rate from the received frame. In step 120, the STA2 calculates the noise margin, which is the difference between the received SNR and the SNR$_{MIN}$, The noise margin information is transmitted to STA1 in step 130. The noise margin is then used to

determine the transmitter power required to obtain the desired carrier-to-noise ratio within the transmitting station and the receiver in BSS. In step 140, the STA1 adjusts the transmission power level and/or the transmission rate based on the adjustment level that was determined in step 120.

5   Although a limited number of STAs is shown in Fig. 1 for illustrative purposes, it is to be understood that the WLAN can support communications between a much larger number of STAs. Thus, the number of STAs in the figure should not impose limitations on the scope of the invention. In such event, each STA keeps track of the noise margin between other STAs within the BSS and to the AP, then each transmitting station may

10   use the noise margin to adjust the transmit power level as it transmits a frame to another STA or to the AP. With non-802.11e WLAN, a STA needs to keep track of the noise margin with the AP only as the STA must transmit frames to its AP. Here, each transmitting station may want to keep track of the noise margin with a selected number of STAs to reduce the complexity. In addition, to prevent using outdated and stale noise margin information, the

15   present invention may adopt the noise margin information lifetime. To this end, whenever STA 2 updates the noise margin with STA 1 by receiving a frame from STA 1, STA 2 sets a timer for each updated noise margin information using the timer 22 of Fig. 2. Hence, the STA 2 will compare the most recent updated time of the frame with the current time when it is to transmit a frame.

20   While the preferred embodiments of the present invention have been illustrated and described, it will be understood by those skilled in the art that various changes and modifications may be made, and equivalents may be substituted for elements thereof without departing from the true scope of the present invention. In addition, many modifications may be made to adapt to a particular situation and the teaching of the present

25   invention without departing from the central scope. Therefore, it is intended that the present invention not be limited to the particular embodiment disclosed as the best mode contemplated for carrying out the present invention, but that the present invention include all embodiments falling within the scope of the appended claims.

7

CLAIMS:

1.   A method for determining the transmission power level and/or transmission
rate among a plurality of stations located within the coverage area of a basic service set
(BSS) in a wireless local area network (WLAN), comprising the steps of:
            extracting a transmission data rate from an incoming frame by a receiving
5   station;
            calculating a noise margin using a ratio of the received signal power to that
required for reliable communication for the extracted data rate; and
            transmitting the noise margin to the incoming frame transmitting station.

10   2.   The method of claim 1, wherein further including the step of adjusting a
transmit power level and/or transmission rate of the outgoing frame from the transmitting
station or other stations based on the received noise margin.

3.   The method of claim 1, wherein the step of
15   calculating a ratio includes determining a signal-to-noise ratio (SNR) of the
received frame; and
            calculating the noise margin for the extracted data rate based on the difference
of the SNR and a minimum acceptable SNR_{MIN} by said receiving station.

20   4.   The method of claim 1, further comprising the step of storing said noise
margin in a memory medium for a predetermined time period.

5.   The method of claim 1, wherein said frame is transmitted by an access point
(AP) located within said basic service set (BSS).

25
6.   The method of claim 1, wherein said frame is transmitted by a transmitting
station located within said basic service set (BSS)or an independent basic service set (IBSS).

8

7.   The method of claim 1, wherein said receiving station is an access point (AP) located within said basic service set (BSS).

8.   The method of claim 1, wherein said receiving station is a mobile unit located within said basic service set (BSS) or an independent basic service set (IBSS).

9.   A method for determining the transmission power level among a plurality of stations located within the coverage area of a basic service set (BSS) in a wireless local area network (WLAN), each station having means for transmitting a frame and means for receiving a frame, the method comprising the steps of:

transmitting a first frame from a transmitting station to a receiving station;

extracting, at said receiving station, a transmission data rate of said received first frame;

calculating a signal-to-noise ratio (SNR) of the first frame;

calculating a noise margin based on the difference of the SNR and a minimum acceptable SNR_{MIN} for the extracted data rate by said receiving station;

transmitting, by said receiving station, the noise margin to said transmitting station;

calculating, by said transmitting station, a new transmit power level and/or transmission rate in response to said calculated noise margin information; and

adjusting, at said transmitting station, the transmit power level and/or transmission rate of a future frame transmitted from said transmitting station to said receiving station based on the calculated noise margin information.

10.   The method of claim 9, further comprising the step of transmitting, by said receiving station, the noise margin to a second station and allowing for an adjustment of the transmission power level and/or transmission rate of said second station based on said calculated noise margin.

11.   The method of claim 9, wherein said receiving station or said transmitting station are mobile units.

12.   A station for transmitting information between a plurality of stations located within the coverage area of a basic service set (BSS) in a wireless local area network (WLAN), said station comprising:

        a receiver circuit for demodulating an incoming signal;

        a processor for (1) extracting a transmission data rate from said incoming signal from a first station, (2) calculating a noise margin using a ratio of the received signal power to that required for reliable communication for the extracted data rate ; and

        a memory, coupled to said processor, for storing said noise margin for a subsequent retrieval.

13.   The apparatus of claim 12, wherein the processor is configured to calculate a signal-to-noise ratio (SNR) for the incoming signal, wherein the noise margin is based on a difference between said SNR of said incoming signal and a minimum SNR_{MIN} for the extracted data rate.

14.   The apparatus of claim 12, wherein said transmitter comprises a modulator for modulating signals indicative of said stored noise margin.

15.   The apparatus of claim 12, wherein said signal is transmitted by an access point (AP) located within said basic service set (BSS).

16.   The apparatus of claim 12, wherein said signal is transmitted by a transmitting station located within said basic service set (BSS) or an independent basic service set (IBSS).

17.   An apparatus for determining the transmission power level between a plurality of stations located within the coverage area of a basic service set (BSS) in a wireless local area network (WLAN), comprising:

        means for receiving an incoming signal from a first station;

        means for demodulating said incoming signal;

        means for extracting a transmission data rate from said incoming signals received therein;

        means for calculating a noise margin using a ratio of the received signal power to that required for a predetermined threshold of communication for the extracted data rate;

        means for transmitting said noise margin to the said first station, and

means for storing said noise margin information for a subsequent retrieval.

18.   The apparatus of claim 17, further comprising a means for affecting an
adjustment of a transmit power level and/or transmission rate of a station in said plurality of
stations, in response to said noise margin.

19.   The apparatus of claim 17, further comprising a means for allowing the
adjustment of the transmission rate and/or transmission rate of said first station.

20.   The apparatus of claim 17, further comprising a means for modulating signals
indicative of said stored noise margin information.

21.   The apparatus of claim 17, wherein said calculated noise margin information
is stored in said storing means for a predetermined time period.

22.   The apparatus of claim 17, wherein said incoming signal is transmitted by an
access point (AP) located within said basic service set (BSS).

23.   The apparatus of claim 17, wherein said signal is transmitted by a transmitting
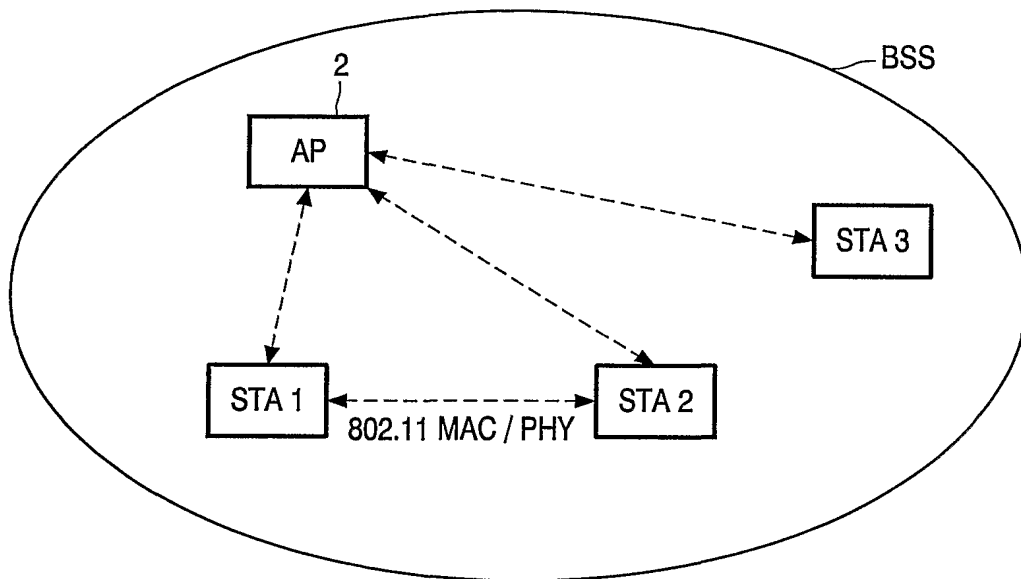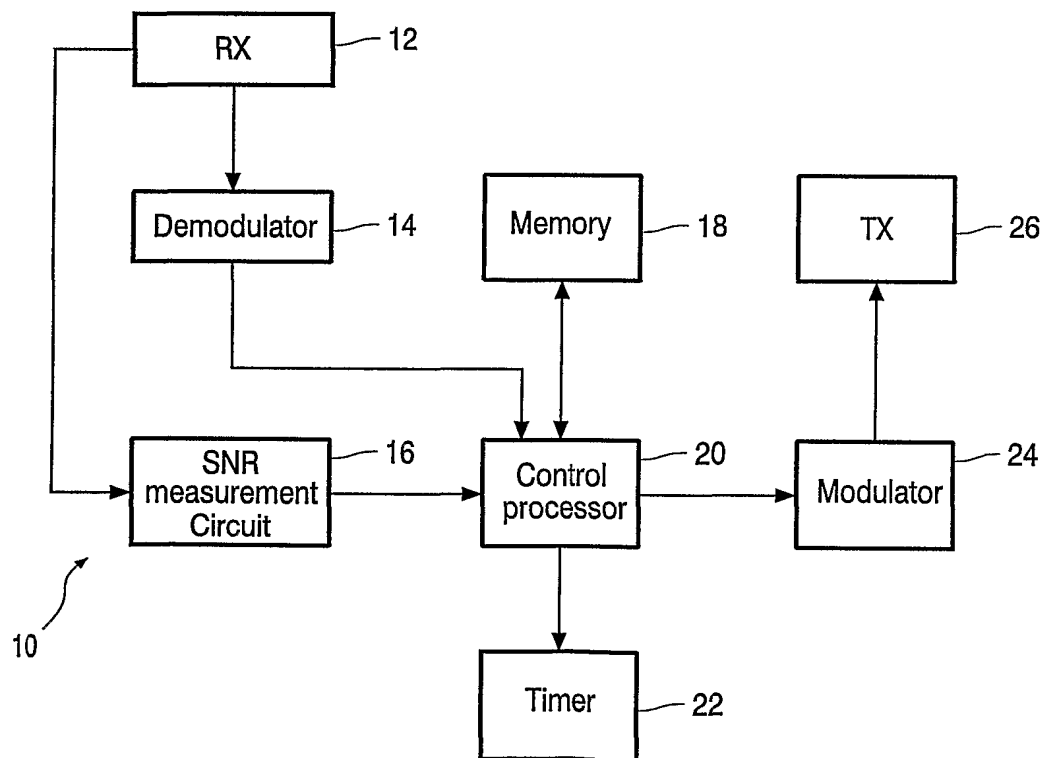station located within said basic service set (BSS) or an independent basic service set (IBSS).
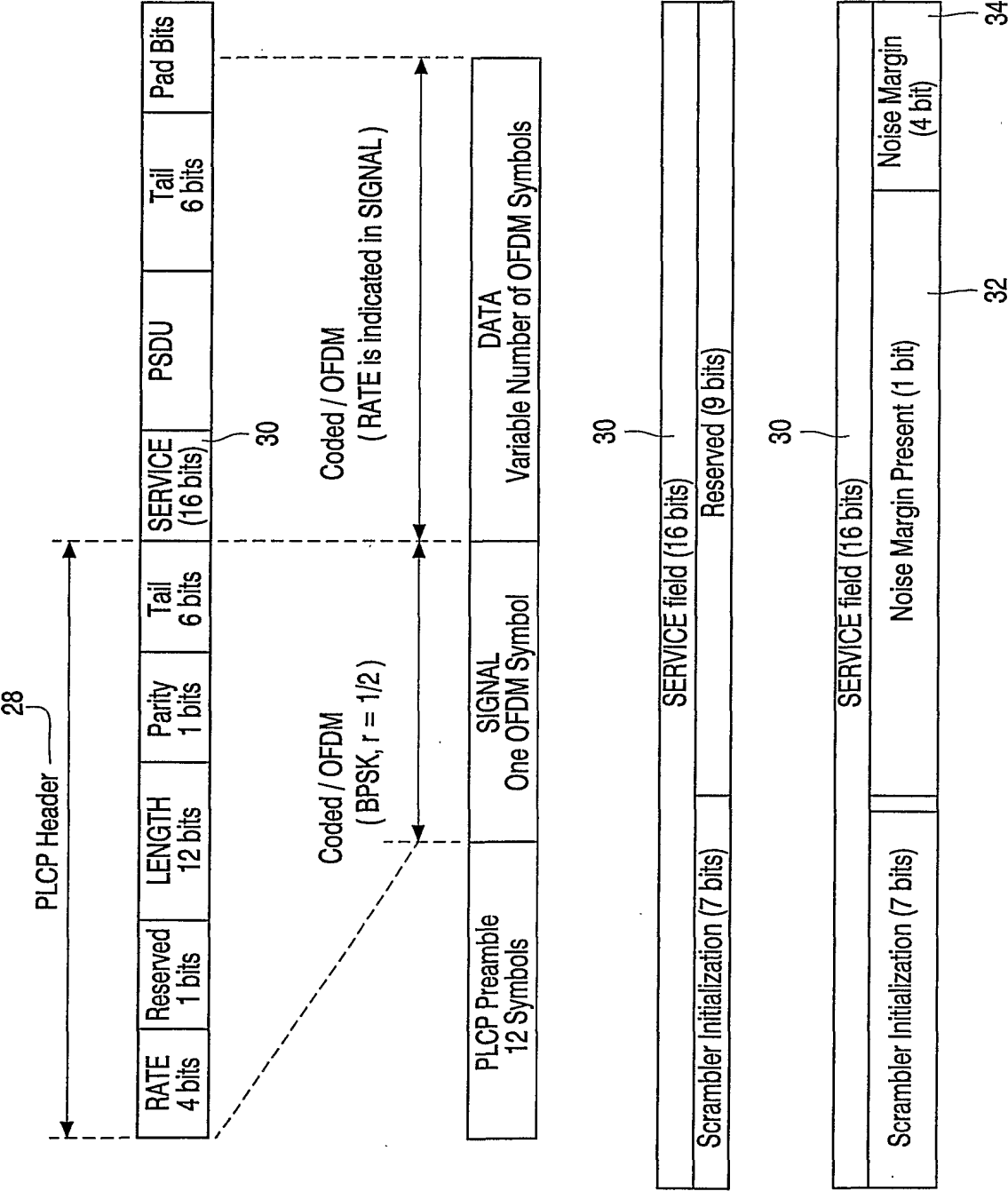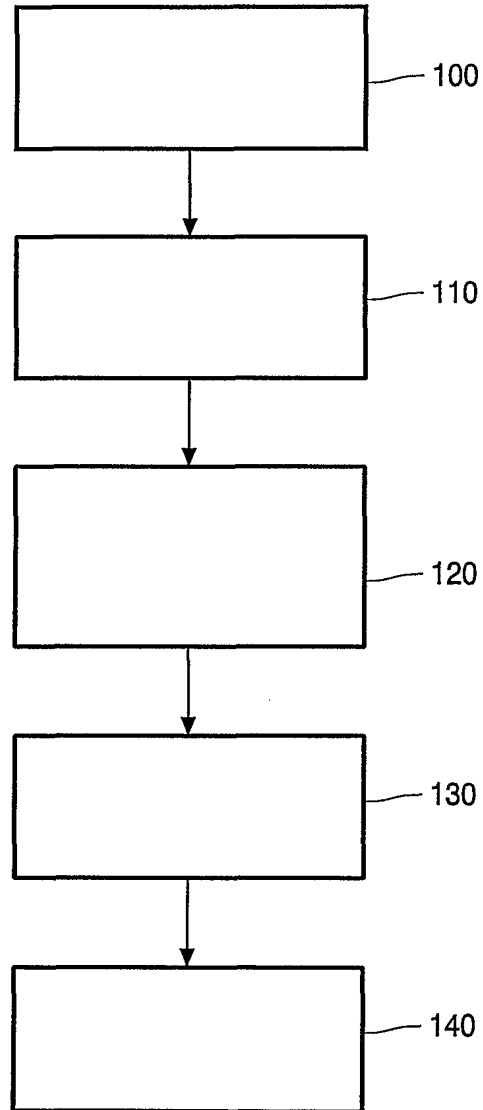
FIG. 1

FIG. 2

| RATE
4 bits | Reserved
1 bits | LENGTH
12 bits | Parity
1 bits | Tail
6 bits | SERVICE
(16 bits) | PSDU | Tail
6 bits | Pad Bits |

PLCP Header ⏤ 28

Coded / OFDM
(BPSK, r = 1/2)

30

Coded / OFDM
(RATE is indicated in SIGNAL)

| PLCP Preamble
12 Symbols | SIGNAL
One OFDM Symbol | DATA
Variable Number of OFDM Symbols |

| Scrambler Initialization (7 bits) | SERVICE field (16 bits) Reserved (9 bits) |

30

| Scrambler Initialization (7 bits) | SERVICE field (16 bits) Noise Margin Present (1 bit) | Noise Margin
(4 bit) |

30   32   34

FIG. 3

FIG. 4

INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7   H04L12/28

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7   H04L   H04Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	KOLENCHERY S S ET AL: "Performance of local power control in peer-to-peer impulse radio networks with bursty traffic" GLOBAL TELECOMMUNICATIONS CONFERENCE, 1997. GLOBECOM '97., IEEE PHOENIX, AZ, USA 3-8 NOV. 1997, NEW YORK, NY, USA,IEEE, US, 3 November 1997 (1997-11-03), pages 910-916, XP010254755 ISBN: 0-7803-4198-8 abstract page 913, left-hand column, paragraph 2.3 -page 914, left-hand column, paragraph 3	1-23

-/--

[X] Further documents are listed in the continuation of box C.   [X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
8 October 2002	14/10/2002

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	Wolf, W

INTERNATIONAL SEARCH REPORT

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	WO 00 04649 A (NOKIA NETWORKS OY ;NAGHIAN SIAMAEK (FI)) 27 January 2000 (2000-01-27) abstract page 5, line 2 -page 11, line 12 figures 1-3	1-23
A	WO 00 77949 A (TIME DOMAIN CORP) 21 December 2000 (2000-12-21) abstract page 18, line 5 -page 21, line 13 page 23, line 24 -page 27, line 12 page 35, line 20 -page 41, line 25 page 58	1-23
A	WO 01 01601 A (NOKIA NETWORKS OY ;HOLMA HARRI (FI); SALONAHO OSCAR (FI)) 4 January 2001 (2001-01-04) abstract page 1, line 23 -page 2, line 15 page 3, line 25 -page 6, line 17 figures 1,3	1-23

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
WO 0004649	A	27-01-2000	FI	981625 A	17-01-2000
			AU	5043699 A	07-02-2000
			EP	1097523 A1	09-05-2001
			WO	0004649 A1	27-01-2000
			JP	2002520983 T	09-07-2002
WO 0077949	A	21-12-2000	AU	5871300 A	02-01-2001
			WO	0077949 A1	21-12-2000
WO 0101601	A	04-01-2001	FI	991448 A	25-12-2000
			AU	5537300 A	31-01-2001
			EP	1188255 A1	20-03-2002
			WO	0101601 A1	04-01-2001